भारतीय मानक

Indian Standard

IS 18171 : 2023

दानेदार उच्च सहताप सामग्रियों के लिए घनत्व और संरंध्रता ज्ञात करना

Determination of Density and Porosity for Granular Refractory Materials

ICS 81.080

© BIS 2023

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in www.standardsbis.in

August 2023 **Price Group 4**

Refractories Sectional Committee, MTD 15

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Refractories Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard is intended for determination of bulk density (BD) and apparent porosity (AP) of granular refractory materials, also known as refractory aggregates. It has been felt necessary to formulate the Indian Standard for bulk density (BD) as well as apparent porosity (AP) measurements of refractory granular material/refractory aggregate, since they form the backbone of the refractory formulations. Apart from product chemistry, the bulk density (BD) and apparent porosity (AP) are important in controlling the final product properties corrosion resistance, strength, modulus of elasticity, thermal expansion, thermal spalling resistance, etc. Against this backdrop, the knowledge of both bulk density (BD) and apparent porosity (AP) of the aggregate is important in controlling the eventual product properties.

The composition of the Committee responsible for formulation of this standard is given in Annex A.

In reporting the results of the test made in accordance with this standard, if the final value, observed or calculated is to be rounded off, it shall be done in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’.

Indian Standard

DETERMINATION OF DENSITY AND POROSITY FOR GRANULAR REFRACTORY MATERIALS

1 SCOPE

This standard covers the method for determining the apparent porosity, bulk density, apparent density and water absorption of granular refractory materials also known as refractory aggregates. This test method does not apply to materials that react with water or materials that hydrate in boiling water.

2 REFERENCES

The standards given below contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of these standards:

IS No.	*Title*
IS 460	Test sieves — Specification:
(Part 1) : 2020	Wire cloth test sieves (*fourth revision*)
(Part 2) : 2020	Perforated plate test sieves (*fourth revision*)
IS 1997 : 2008/ ISO 385 : 2005	Laboratory glassware — Burettes (*third revision*)
IS 2619 : 2018/ ISO 3819 : 2015	Glass beakers — Specification (*third revision*)
IS 4041 : 2006/ ISO 836 : 2001	Terminology of refractories (*first revision*)

3 TERMINOLOGY

For the purpose of this standard, the following definition, in addition to those given in IS 4041, shall apply:

3.1 Bulk Density (BD) — Ratio of mass and volume of all 3 types of pores, that is, open, channel and closed pores, present in a material plus volume of the solid.

3.2 Apparent Density (AD) — Ratio of mass and volumes of open and channel pores plus volume of the solid. In other words apparent density, unlike bulk density, does not account for closed pores present in the test specimens.

4 SAMPLING

4.1 Lot

In any consignment, all the containers/bags holding the refractory aggregates/granular material of the same type and grade, manufactured by the same supplier under similar conditions of production shall be grouped together to constitute a lot. The maximum mass of any lot shall, however, be limited to 50 tonne.

4.2 Sample Size

It is recommended that a minimum quantity of 50 kg should be collected for evaluation. As refractory granular materials are normally supplied in 50 kg containers/bags, the number of containers/bags shall be selected at random on the basis of Table 1. In case the content of the supplied bags/containers differs from 50 kg, the numbers of collected bags, for a given lot size, should be such that the collected refractory granular material/aggregate quantity, in terms of weight, is greater than that specified in Table 1. For example, if a supplied bag contains 30 kg of refractory granular mass/aggregate and the lot size is 9 tonne, 2 bags instead of 1, that is, 60 kg, should be collected for test sample preparation.

The selected containers/bags shall be emptied on a clean and dry surface. The material should be thoroughly mixed and reduced to 1 kg by repeated coning and quartering.

Table 1 Numbers of Bags/Containers to be Selected for Different Lots

(*Clause* 4.2)

Sl No. (1)	Lot Size, in Tonne (2)	Number of 50 kg Containers/Bags to be Selected as Samples (3)
i)	Up to 10	1
ii)	10 to 25	2
iii)	Over 25 up to 50	4

5 APPARATUS REQUIRED

a) Laboratory crusher for crushing samples;
b) Sieve of aperture size ranging between 2 mm to 4 mm conforming to IS 460 (Part 1) or IS 460 (Part 2);
c) Drying oven, adjustable to 105 °C to 110 °C;
d) Riffle, spatula or trowel, for sample quartering;
e) Weighing balance, having sensitivity 0.01 g;
f) Hot plate or heater;
g) Beakers of capacity 250 ml conforming to IS 2619 or thin cloth pouches and container; and
h) Calibrated burette of capacity 100 ml, graduated in 0.2 ml; conforming to the requirements of IS 1997.

6 TEST SAMPLE

6.1 The sample obtained in **4.2**, shall be screened dry through 2 mm and 4 mm sieves. Collect size fractions which pass through 4 mm sieve and are retained on 2 mm sieve. The objective is to collect a minimum 300 grams of sample which passes 4 mm sieve and retained on 2 mm sieve. If it is necessary, adjust the crushing process for generation of minus 4 mm and plus 2 mm size fractions of the material and/or if required, collect greater than 1 kg of sample at stage **4.2**.

6.2 Blow clean dry air over the generated plus 4 and minus 2 mm size material to make it dust free. If required, wash the sample collected subsequent to sieving, in a stream of tap water for at least 5 min or until all the dust is removed. Oven-dry the material overnight at 105 °C to 110 °C till the sample attains constant weight.

7 PERSONAL PROTECTIVE EQUIPMENT (PPE'S) REQUIREMENT

The following personal protective equipment should be used while performing the test.

a) Safety shoes;
b) Hand gloves; and
c) Safety goggles.

8 PROCEDURE

8.1 Divide the dried sample further by quartering or riffling to obtain the portion for testing. Weigh 100 g of this sample to the nearest 0.01 g and record as dry weight (W_d).

8.2 Place the sample in a beaker of water and boil for 2 h. Alternatively, the sample may be taken in a cloth pouch and boiled in a container of water, taking care that the pouch does not touch the sides or bottom of the container. During boiling, the grains shall be completely covered with water. Cool the sample to room temperature by running cold water into the beaker (or keeping the pouch in a tray of cold water).

8.3 Decant the excess water and place the grains on a damp towel. Use a towel that is well saturated with water, to remove surface water from the grains. Blot lightly to avoid removing water from the pores. Removal of surface water will be complete when grains no longer adhere to each other.

8.4 While performing the steps of the test procedure given in **8.2** and **8.3**, it should be ensured that no material is lost in the process. Weigh this sample to the nearest 0.01 g and record as soaked weight (W_s).

8.5 Take approximately 50 ml of water in a 100 ml burette. Allow it to stand until drops of water on the sides settle into the body of water. Note the exact meniscus level in the burette.

8.6 Pour grains into the burette and shake till all grains and water-droplets settle into the body of water with no air bubbles attached. Read the new meniscus level immediately and record the difference between the first and second readings as volume of grains (V) in cm^3.

9 CALCULATION

Calculate the water absorption, bulk density, apparent porosity and apparent density using the following formulae:

a) Water absorption, in percent = $\frac{W_s - W_d}{W_d} \times 100$

b) Bulk density (BD), in g/cm^3 = $\frac{W_d}{V}$

c) Apparent Porosity (AP), in percent = $\frac{(W_s - W_d)}{(V \times \rho)} \times 100$

d) Apparent density, in g/ cm^3 = $\frac{W_d}{V - \left\{ {(W_s - W_d)}/{\rho} \right\}}$

where

W_s = soaked weight of the sample, in grams;
W_d = dry weight, in grams;
V = volume of grains, in cm^3; and
ρ = density of water in g/cm^3.

NOTE — In the above formulae, use 'ρ' = 1 g/cm^3.

10 TEST REPORT

The test report shall include at least the following information:

a) How the sample is taken;

b) Size of grains of the sample measured;

c) The values of apparent porosity, bulk density, apparent density and water absorption (if more than one sample was tested, state the number of samples tested and arithmetic average (mean) of results as well as the range between the highest and lowest values obtained);

d) The name of testing establishment; and

e) Date of test.

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Refractories Sectional Committee, MTD 15

Organization	*Representative(s)*
SKG Refractories Ltd, Kolkata	Dr Arup Kumar Chattopadhyay **(*Chairperson*)**
Calderys India Refractories Limited, Nagpur	Dr I. N. Chakraborty Shri Santanu Basak (*Alternate* I) Dr Saumen Sinha (*Alternate* II)
CSIR - Central Glass and Ceramic Research Institute, Kolkata	Dr H. S. Tripathi
Dalmia Institute of Science & Industrial Research, Sundargarh	Dr Prema Ranjan Rauta Shri Sudhir Kumar Panda (*Alternate* I) Shri Lalit Mohan Choudhury (*Alternate* II)
Engineers India Limited, New Delhi	Shri Prasenjit Saha Shri Biswarup Sarkar (*Alternate* I) Shri Prasenjit Pal (*Alternate* II)
Hindalco Industries Limited, New Delhi	Dr Nageswar Kapuri Shri P. Saravanan (*Alternate* I) Shri Tapas Chowdhury (*Alternate* II)
IFGL Refractories Limited, Kalunga	Shri S. D. Majumdar Shri Sajahan Mandal (*Alternate*)
Indian Refractory Makers Association, Kolkata	Dr Arup Ghosh Shri Anirbandip Dasgupta (*Alternate*)
Mahakoshal Refractories Private Limited, Katni	Dr Sukumar Adak Shri Shyamalendu Kabiraj (*Alternate*)
Maithan Ceramic Limited, Chirkunda	Shri S. N. Su Shri J. N. Chakraborty (*Alternate*)
MECON Limited, Ranchi	Shri S. Banerjee Shri B. Bera (*Alternate*)
M N Dastur and Company Private Limited, Kolkata	Shri Saurav Ghosal Shri Arindam Chakraborty (*Alternate* I) Shri Partha Pratim Biswas (*Alternate* II)
National Aluminium Company Limited, Bhubaneswar	Shri Pranab Kumar Das Shri Satyakam Nayak (*Alternate*)
National Council for Cement and Building Materials, Faridabad	Dr S. K. Chaturvedi Shri Giasuddin Ahamed (*Alternate*)
OCL India Limited, Rajgangpur	Dr J. K. Sahu Dr A. K. Patnaik (*Alternate*)

Organization	*Representative(s)*
SKG Refractories Ltd, Kolkata	SHRI GAUTAM CHOWDHURY SHRI ABHISHEK SARKAR (*Alternate*)
Rashtriya Ispat Nigam Limited, Visakhapatnam	SHRI S. K. BHATTACHARYA SHRI P. S. PAUL (*Alternate*)
Steel Authority of India Limited (SAIL), Bhilai Steel Plant, Bhilai	SHRI SANDEEP SRIVASTAVA MS D. SATYA DEVI (*Alternate* I) SHRI AMIT ROY (*Alternate* II)
Steel Authority of India (SAIL), Centre for Engineering and Technology (CET), Ranchi	SHRI SURENDRA PRASAD SHRI AISHWARYA DEWANGAN (*Alternate*)
Steel Authority of India Limited (SAIL), Research & Development Centre for Iron & Steel (RDCIS), Ranchi	SHRI M. K. KUJUR SHRIMATI A. BHATTACHARYA (*Alternate*)
Tata Steel Limited, Kolkata	SHRI BAJENDRA SHRI GOUTHAM GHOSH (*Alternate* I) SHRI PRASANTA PANIGRAHI (*Alternate* II)
TRL Krosaki Refractories Limited, Jharsuguda	SHRI ARUP KUMAR SAMANTA SHRI S. K. SUBUDHI (*Alternate* I) SHRIMATI RAJASHREE SWAIN (*Alternate* II)
In Personal Capacity (*Flat 1 A, Himkunj Cooperative Society, Block 1st Number – 167 B. P. Township, Kolkata*)	DR BARUN DEB MUKHERJEE
In Personal Capacity (*Plot No BC 224, Sector-1, Salt Lake, Kolkata*)	SHRI K. K. PAUL
BIS Directorate General	SHRI SANJIV MAINI, SCIENTIST 'F'/SENIOR DIRECTOR AND HEAD (METALLURGICAL ENGINEERING) [REPRESENTING DIRECTOR GENERAL (*Ex-officio*)]

Member Secretary
SAAQIB RAAHI
SCIENTIST 'B'/ASSISTANT DIRECTOR
(METALLURGICAL ENGINEERING), BIS

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 2016 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Head (Publication & Sales), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website-www.bis.gov.in or www.standardsbis.in.

This Indian Standard has been developed from Doc No.: MTD 15 (13606).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.gov.in

Regional Offices: *Telephones*

Central : 601/A, Konnectus Tower -1, 6th Floor, DMRC Building, Bhavbhuti Marg, New Delhi 110002 — 2323 7617

Eastern : 8th Floor, Plot No 7/7 & 7/8, CP Block, Sector V, Salt Lake, Kolkata, West Bengal 700091 — 2367 0012, 2320 9474

Northern : Plot No. 4-A, Sector 27-B, Madhya Marg, Chandigarh 160019 — 265 9930

Southern : C.I.T. Campus, IV Cross Road, Taramani, Chennai 600113 — 2254 1442, 2254 1216

Western : Plot No. E-9, Road No.-8, MIDC, Andheri (East), Mumbai 400093 — 2821 8093

Branches : AHMEDABAD. BENGALURU. BHOPAL. BHUBANESHWAR. CHANDIGARH. CHENNAI. COIMBATORE. DEHRADUN. DELHI. FARIDABAD. GHAZIABAD. GUWAHATI. HIMACHAL PRADESH. HUBLI. HYDERABAD. JAIPUR. JAMMU & KASHMIR. JAMSHEDPUR. KOCHI. KOLKATA. LUCKNOW. MADURAI. MUMBAI. NAGPUR. NOIDA. PANIPAT. PATNA. PUNE. RAIPUR. RAJKOT. SURAT. VISAKHAPATNAM.

Published by BIS, New Delhi